IMPACT OF VARIABLE RATE NITROGEN APPLICATIONS ON GRAIN YIELD AND PROTEIN *PI: Dr. Dave Grafstrom & Rob Proulx*

INTRODUCTION

Precision agriculture techniques involve crop management at the sub-field level. One of these techniques, variable rate nitrogen (VRN) application, has the potential to improve soil fertility management through the reallocation of nitrogen fertilizer from lower-productivity areas of the field to higher-productivity areas of the field. Many growers who implement VRN applications utilize the technical assistance of outside consultants to create variable rate maps, performing zone-based soil sampling, and/or making variable rate fertilizer applications. As such, growers want to know if these added costs are yielding a positive economic return.

The On Farm Research Network (OFRN) offers a unique opportunity to investigate the effectiveness of VRN in commercial scale wheat production, as these research trials are a challenge to conduct with traditional small- plot research methods. Through the determination of our cooperators, their agronomists, and OFRN staff, we were able to implement this study at two locations in 2017. This project follows MN Wheat's OFRN philosophy of conducting relevant research through simplicity in trial design.

The objective of this research was, at each location, to compare a VRN application method to a flat nitrogen application rate. The cooperating growers and their crop consultants determined the nitrogen rates used in the study.

MATERIALS AND METHODS

Site descriptions for the two 2017 locations are presented in Table 16. There were two treatments in each location: (1) a VRN application based on a zone map created by a crop consultant, and (2) a flat rate of N that the grower would apply under a whole-field management approach.

Table 16. Agronomic details for VRN trials in 2017.

	Location	
	1	2
	Elbow Lake	Red Lake Falls
Planting Date	4/8	5/12
Harvest Date	8/12	8/25
Rainfall Total (in)	13.77"	9.72"
Rainfall 11 Days after Application (in)	N/A	1.64"
Previous Crop	Soybean	Soybean
Soil Type	Loam, well drained	Fine sandy loam
Variety	Jenna	Linkert

At Location 1, the fertilizer spreader operator skipped the flat-rate areas when making the VRN application, followed by the application of the flat rate within the skipped areas (Figure 1). At Location 2, the crop consultant modified the VRN map to include the flat-rate strips (Figure 2). At both locations, the plot area featured alternating 70-foot wide strips of VRN and the flat rate of N. In addition, at Location 2, the nitrogen was split-applied due to the topography and soil types of this particular field. The Location 2 trial was initiated in early June, before a forecasted rain event, with Agrotain-treated urea. Agrotain is a urease inhibitor that protects surface-applied nitrogen from ammonia volatilization. Rainfall data was collected with the services of Climate Fieldview.

At Location 1, all of the fertilizer was applied preplant and incorporated. While the split application was justifiable at Location 2, the preplant application method is how we would like to have these VRN trial locations set up in the future. This is because of the extra planning and work that is involved with the split application method.

Field scale equipment was used in all field operations. At harvest, individual plot weights were taken with a weigh wagon provided by MN Wheat or by a scale on the grower's grain cart. MN Wheat owns one weigh wagon and borrows three others. Reported yields are adjusted to 13.5% grain moisture. Grain subsamples were collected from each plot with an attachment to the weigh wagon's auger as the grain is augured out of the weigh wagon and into a truck; the attachment takes a small stream of continuous grain. In those instances where the weigh wagon was not used, a piece of PVC pipe captured subsamples from the stream of grain as it was being unloaded from the grain cart into a truck. Subsamples were immediately analyzed for harvest moisture and grain test weight with a Dickey John mini-GAC plus tester. Subsamples were later analyzed for grain protein at the Northern Plains Grain Inspection Service.

Statistical analysis was performed using SAS and R computer software. Analysis of variance (ANOVA) for yield, protein, test weight, and profit were conducted for each individual location, considering treatment and replication as fixed effects. Each variable was also analyzed using ANOVA combined across locations, considering treatment as a fixed effect, replication and location as random effects, and heteroscedastic residual variance by location.

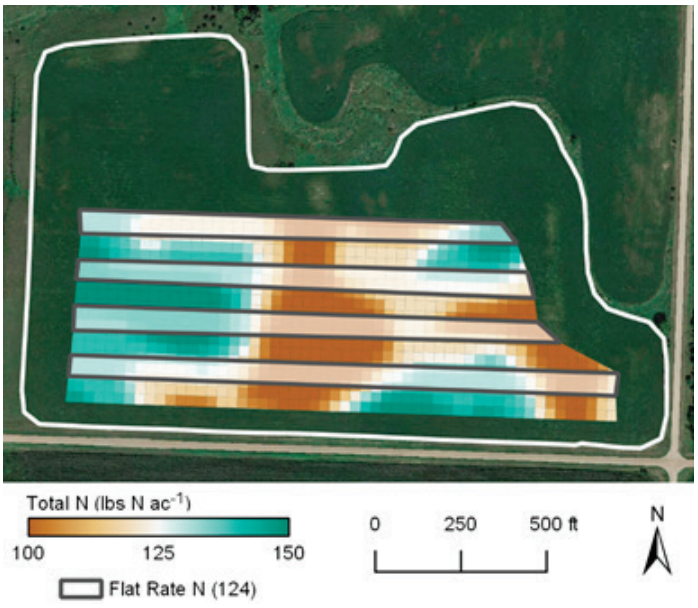

Figure 1. Map of Location 1 VRN trial, 2017.

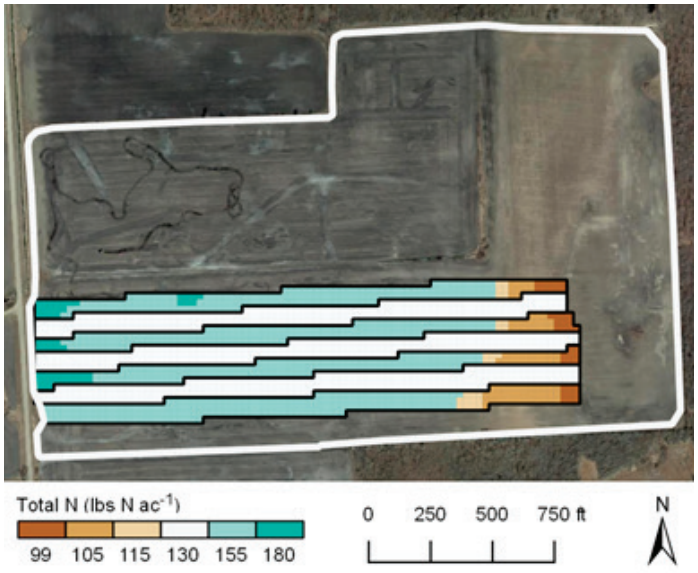

Figure 2. Map of Location 2 VRN trial, 2017.

RESULTS AND DISCUSSION

Yield, test weight, and protein results are presented in Table 17. VRN applications did not have a statistically significant effect on test weight or yield in either location. Similar results were observed in the combined analysis. VRN application did not have a statistically significant impact on grain protein at Location 1, but VRN increased grain protein content by 0.7% at Location 2 and by 0.6% for the combined analysis.

Table 17. Effect of variable rate nitrogen compared to a flat rate of nitrogen on test weight, grain protein and yield at two locations in NW MN.

Treatment	Location		
	1	2	combined
	Test Weight (lb/bu)		
VRN	60.3	60.3	60.3
Flat Rate N	60.5	60.3	60.4
LSD (0.05)	NS	NS	NS
LSD (0.10)	NS	NS	NS
	Protein (%)		
VRN	13.6	13.9	13.8
Flat Rate N	13.2	13.2	13.2
LSD (0.05)	NS	0.6	0.3
LSD (0.10)	NS	0.4	0.2
	Grain Yield (bu/ac)		
VRN	77.4	76.9	77.2
Flat Rate N	76.4	74.8	75.3
LSD (0.05)	NS	NS	NS
LSD (0.10)	NS	NS	NS

An economic analysis of VRN applications is presented in Table 18. The economic analysis does not include all production costs; instead, this analysis considers the marginal cost of VRN applications when compared to whole-field broadcast applications.VRN applications were profitable at each location and in the combined analysis of both locations, but the realized profits were not large enough to be considered statistically significant. The results also suggest that the increased revenue generated by small increases in yield was sufficient to offset the expenses associated with the VRN applications, but that yield increases by themselves would not bring meaningful profit. Rather, any profits due to the VRN treatments resulted from increased grain protein content. Thus, it seems that the status of grain protein discounts and premiums is critically important when evaluating the profitability of VRN applications.

At least five more sites are planned for the 2018 growing season. Presently, it is difficult to draw meaningful conclusions from just two locations and one year's data. However, additional years and locations should improve the validity of conclusions from this research, providing support for growers looking to evaluate VRN within their own enterprises. It's hypothesized that VRN will show the most benefit on the fringe of the Red River Valley (RRV), as these areas tend to display greater in-field variability in soil type. However, growers located within the RRV will be welcome to participate in future studies.

Table 18. Economic analysis of variable rate nitrogen vs. flat rate nitrogen at two locations in NW MN, 2017.

	Location		
	1	2	Combined
Yield – VRN	77.4	76.9	77.2
Yield – Flat Rate N	76.4	74.8	75.3
Protein – VRN	13.6	13.9	13.8
Protein – Flat Rate N	13.2	13.2	13.2
Urea – VRN	231	212	—
Urea – Flat Rate N	230	175	—
Yield gain/loss	1.0	2.1	1.9
Protein gain/loss	0.4	0.7	0.6
Yield gain/ac[1]	$5.85	$12.60	—
Protein gain/ac[2]	$11.62	$22.04	—
VRN cost/ac[3]	−$5.65	−$13.22	—
Profit	$11.81	$21.43	$18.54
Profit LSD (0.05)	NS	NS	NS
Profit LSD (0.10)	NS	NS	NS

[1] Wheat = $6.00/bu

[2] Protein = $0.10 per fifth above 14 and up to 15, +$0.02 per fifth over 15, -$0.08 per fifth under 14

[3] $345/ton for extra urea, $1.75/ac to make VRN map, $4.75/ac for VRN soil sampling (vs. $70/field for composite sampling), $1.00/ac extra for VRN application

CONCLUSIONS

After one year of this trial, at two locations, any conclusions drawn from the presented analyses are strictly preliminary. Nonetheless, the 2017 studies suggest the following:

1. VRN applications have the potential to increase grain protein content by at least 0.5%.
2. Observed increases in grain yield were small and not statistically significant.
3. Revenues associated with the modest yield increases would not likely be sufficient to justify the increased cost of VRN applications.
4. Increased grain protein content, due to VRN applications, may be sufficient to improve grower profitability, dependent on the status of grain protein premiums/discounts and any associated yield increases due to VRN applications.